Beyond language shift

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Beyond language shift:

Spatial cognition among the Ixcatecs in Mexico

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Abstract

Recently there has been a renewed interest surrounding the role that language plays in the shaping of cognition based on the study of spatial relations with a particular attention to Mesoamerican languages (Li & Gleitman, 2002; Li et al., 2011; Le Guen, 2011). Since Brown & Levinson (1993), several studies have shown that speakers of Mesoamerican languages largely prefer non-egocentric strategies in the solution of nonverbal tasks and that this preference strongly aligns to the spatial expressions found in these languages (O'Meara & Peréz Báez, 2011). Moreover, it has been argued that contact with Spanish increases the use of egocentric responses (Bohnemeyer et al., 2011). The present paper engages in this discussion with new evidence from a Mexican community which has shifted from a Mesoamerican language, Ixcatec, to Spanish during the twentieth century. This paper presents three studies consisting of nonverbal, memorization tasks, conducted with 52 monolingual Spanish speakers from Santa María Ixcatlán. According to the neo-Whorfian approach, the residents of Santa María Ixcatlán should strongly favor the Spanish-related egocentric responses. Against this assumption, however, our study shows that the geocentric responses are predominant among the Ixcatecs. This result clearly indicates that frames of reference are culturally-defined. However, it is difficult to draw any conclusions with respect to the rise of

the frames of reference: it could be argued that frames of reference are influenced by culture and environmental factors independent of language, but it could also be said that although frames of reference arise in relation to the linguistic expressions, they do not disappear in case of language shift but persist in cognitive representations among the members of a stable, rural community.

Keywords: Spatial cognition; Linguistic relativity; Frames of reference; Language loss; Mexico

1. Introduction

In the last two decades, a number of cross-cultural studies have addressed the role that language plays in the shaping of spatial cognition. On the one hand, defenders of the 'neo-Whorfian' approach, a development of the very influential linguistic relativity hypothesis (Whorf, 1956), argue that language, as a fundamental aspect of culture, profoundly impacts various components of human cognition and that it is crucial among others to the cognitive representation of space, e.g. Brown & Levinson, 1992; Pederson et al., 1998; Bowerman & Levinson, 2001; Levinson, 2003; Haun et al., 2011. On the other hand, tenants of the 'universalist' approach consider language to be subdued to cognitive processes, e.g. Li & Gleitman, 2002; Li et al., 2011. This perspective favors the notion that extra-linguistic factors are responsible for the shaping of cognitive representations of space, namely environment, type of community, education, etc.

'Frames of reference' refer to the use of coordinate systems for construing spatial relations (Levinson, 2003: 24-61), in which a referent A, dubbed 'figure', is located with respect to a referent B, dubbed 'ground' (Levinson, 2003: 41). The frames of references can

be categorized as ‘egocentric’, ‘intrinsic’, and ‘geocentric’ in the terms of Haun et al. (2011: 72) and Le Guen (2011). In the ‘egocentric’ frame of reference the ‘ground’ is the observer’s viewpoint (this is termed ‘relative’ frame of reference in Levinson 2003: 53). The ‘intrinsic’ frame of reference is one in which the properties of a referent, which serves as the ground, such as its ‘front’, ‘back’, and ‘sides’, are the focus in relation to another referent, which is the ‘figure’ (also known as ‘object-centered’ in Carlson-Radvansky & Irwin, 1993; Li & Gleitman, 2002). Last, in the ‘geocentric’ frame of reference, the ‘ground’, with respect to which a ‘figure’ is located, is some environmental entity or cardinal point (see ‘absolute’ frame of reference in Levinson, 2003: 66).

Mesoamerican languages have been central to the discussion on spatial cognition as it is found that terms for cardinal points are more commonly used as spatial identifiers than observer-based directions in both large-scale and small-scale descriptions (Brown & Levinson, 1993; Bohnemeyer et al., 2011; O’Meara & Peréz Báez, 2011). For example, studies by Brown & Levinson (1992) show that although languages such as Tzeltal (Mayan) possess lexical items that refer to ‘left’ or ‘right’, the use of such lexical items is rare in spatial descriptions and is generally restricted to body parts. Brown and Levinson claim that the scarce use of these items shapes Tzeltal speakers’ cognitive ability to recognize these terms in material form. However, Li et al. (2011), argue that Tzeltal speakers’ cognitive abilities are independent of language and that speakers of Tzeltal perform successfully in tasks that require either an egocentric or an absolute solution.

While these discussions have unearthed important inquiries regarding the effect of language on human cognition, we believe that they may be supplemented by another perspective that takes a glimpse into a more complex situation following language shift. In such a circumstance, we may see the real-time effects of language on cognition. As Li and Gleitman put it with respect to the use of snow-related vocabulary among Eskimos: “Would

such Eskimo populations be affected in their discrimination of snow types if they continued to live where and as they now do, but came to speak English rather than an Eskimo language?" (Li & Gleitman, 2002: 272). By examining spatial language and cognition in a community in which the native language is practically extinct, we may more closely identify what features are unique to the semantic organization stemming from the disappearing language and how they survive the shift to a language with a distinct system of spatial relations.

In this paper, we thus test the neo-Whorfian prediction for a Mexican community which has shifted during the twentieth century from the Ixcatec language (Otomanguean) to Spanish (Indo-European). Ixcatec is nowadays a critically endangered language, spoken by just four fluent speakers, all in their 80s, residing at the municipality of Santa María Ixcatlán, State of Oaxaca. Three nonverbal rotation tasks, inspired by "Animals in a row" (Brown & Levinson, 1993; Levinson, 2003), aim at examining the effect of language shift on spatial cognition among 52 Ixcatecs out of the 400 residents of the Ixcatec community.

The three studies show that the intrinsic, the geocentric, and the egocentric frames of reference are all available in the community, but that the geocentric and intrinsic frames, which are associated to the indigenous languages of Mexico, are the most frequent frames used among the Ixcatecs in the memorization tasks. This result thus demonstrates that the frames of reference which have been reported for several Mesoamerican languages are encountered in a Mesoamerican community that no longer speaks a Mesoamerican language.

Map 1. Santa María Ixcatlán, State of Oaxaca, Mexico

2. The nonverbal experiments

2.1. Goals and predictions

In order to test cognitive preference in the spatial domain among the Ixcatecs we conducted three nonverbal memory tasks. The tasks were inspired by the Max Planck Institute's task "Animals in a row" (Brown & Levinson, 1993; Levinson, 2003).

Based on the literature on spatial language and cognition, we can formulate the following hypotheses:

Hypothesis 1. It is widely admitted that Mesoamerican languages tend to use geocentric or intrinsic frames of reference, including in small-scale arrangements (Bohnemeyer et al., 2011; O'Meara & Peréz Báez, 2011). In the neo-Whorfian perspective, we expect the Spanish monolingual Ixcatecs not to use any non-egocentric frames of reference in the nonverbal rotation task since they no longer speak a Mesoamerican language for the past four generations.

Hypothesis 2. Speakers of Mesoamerican languages are reported to use egocentric systems the least but that their use increases with the use of Spanish (Bohnemeyer et al.,

2011; O'Meara & Peréz Báez, 2011). In accordance to this observation, we expect the Ixcatecs to more frequently use the egocentric system since the entire community is monolingual in Spanish with the exception of less than four fluent speakers of Ixcatec and a handful of semi-speakers who can only understand the language.

Hypothesis 3. The universalist approach predicts that frames of reference depend on extra-linguistic factors, such as education (Bohnemeyer et al., 2011). According to this hypothesis, the most educated speakers will make lesser use of the geocentric frames of reference and the least educated speakers will use the geocentric strategy the most. However, knowing that the Ixcatec participants had at best attended middle-school, it is difficult to test this prediction. We thus conducted the nonverbal task among young Ixcatecs, ages 10-11, who are currently attending primary school.

Hypothesis 4. Li & Gleitman (2002) stress the significance of salient environmental features in the resolution of spatial tasks. As all community members live in the same location, the prediction is that there would be no change on the selected frame of reference for the Ixcatec participants, independent of the language shift that has taken place during the twentieth century from a Mesoamerican language to Spanish. Also, according to this approach, the presence of a salient feature of the environment is expected to influence the results for tasks conducted outdoors (environmental features are visible) as opposed to tasks conducted indoors (no visibility to the surroundings).

2.2. Study 1

2.2.1. Goals and predictions

Knowing that Mesoamerican languages generally code intrinsic relations between two objects (O'Meara & Peréz Báez, 2011; for Ixcatec Adamou, in press), we opted for the use of a chair

to distinguish between three possible frames of reference: the intrinsic, the geocentric, and the egocentric. We chose a chair because it is an everyday object, familiar to all participants. Due to the chair's salient features, we expected the participants to strongly prefer the intrinsic frame of reference in this task.

2.2.2. Material

The Ixcatec participants were presented with a stimulus consisting of three everyday objects, of similar size: a soap bar, a matchbox, and a candle.

2.2.3. Participants

A total of 37 Spanish monolingual Ixcatecs participated in this study. 19 participants were below the age of 30, 12 between ages 31 to 60, and 6 above the age of 61. 17 men and 20 women participated in the study. 23 participants attended at most primary school and 13 completed secondary education. Spearman's correlation test shows there were significant correlations between Age and Education ($r = -0.5$, $n = 41$, p (two-tailed) = .0008).

The diverse sample size and characteristics were based upon the acceptance of the community members at an informal level. Some of the participants were gathered by chance encounters while others were part of existing social networks due to previous research conducted in the village. There was no financial compensation for the participation in the study. As a form of thanking the participants, once the experiment was fully conducted amongst the family members, the researchers provided an explanation of the tasks and the results to interested parties.

2.2.4. Procedure

The experiment did not take place in a laboratory and was adapted to the fieldwork setting. For example, due to the advanced age of several participants, it was not appropriate to ask them to travel to a "laboratory-like" location. Instead, the interviewers visited the participants in their individual houses. While the orientations were kept consistent, the experiment was conducted inside the house or in the yard. Moreover, the number of repetitions was limited since the task proved to be extremely tiresome for the eldest speakers who sometimes have mobility difficulties.

The three items — the soap bar, the matchbox, and the candle — were placed in a row on top of the seat of a chair. The back of the chair faced north, towards the main mountains of the village, and so did the participant. The participant was asked to memorize the placement of the objects and to reposition them. In order to solidify the process the participants were asked to place the objects on the chair as a test-run. A picture was taken of the objects facing the participant. The participants were then rotated 180 degrees with respect to the first setting. This time the back of the chair faced west, whereas the participants faced south. The purpose of placing the chair at a 90-degree rotation was in order to clearly distinguish between an intrinsic, an egocentric, and a geocentric frame of reference. In this position, the participants were asked to put the objects down as they remembered them from the previous setting. The instructions were, e.g. "Could you please put the objects the way they were?" This procedure was repeated twice, with a random change in the order of the objects. The task lasted five minutes.

2.2.5. Coding and analysis

An excel file was created in order to include information about the speaker, age, sex, and education. The frame of reference was then coded as geocentric, egocentric, or as an error if

the setting was not correctly replicated. The preference was then counted for each frame of reference that the participants chose to use.

Generalized linear mixed models (glmer) were constructed using the "lme4" package (Bates et al. 2015) in R (R Core Team, 2013) to analyze the results. The dependent variable is the counts for each frame of reference, and the independent variable is the three frame types (egocentric, geocentric, intrinsic). Speaker is coded as a random factor. Education (primary vs. secondary), Sex (male vs. female), and Location (indoors vs. outdoors) were the fixed factors. Since Age is correlated with Education (r = -0.5, n= 41, *p* (two-tailed) = .0008), and including both factors violates the assumptions of glmer models, Age has been excluded from further analyses.

2.2.6. Results

In this task, all three frames of reference were used by the Ixcatec participants. In the intrinsic response, no matter the rotation of the participant, the objects were always placed in relation to the back of the chair; see Fig. 1a and Fig. 1b. In the geocentric frame of reference, the participants positioned the objects with respect to the cardinal points, as shown in Fig. 2a and Fig. 2b. In the egocentric frame of reference, the participants placed the objects with respect to themselves, as illustrated in Fig. 3a and Fig. 3b.

Fig. 1a. Participant facing north: the soap bar is closest to the back of the chair

Fig. 1b. Participant facing south: the soap bar is closest to the back of the chair (intrinsic frame of reference)

Fig. 2a. Participant facing north: the soap bar is at the northernmost side of the chair

Fig. 2b. Participant facing south: the soap bar is at the northernmost side of the chair (geocentric frame of reference)

Fig. 3a. Participant facing north: the soap bar is furthest from the speaker

Fig. 3b. Participant facing south: the soap bar is furthest from the speaker (egocentric frame of reference)

In the chair task, there are general differences between the three frames of reference (loglikelihood is -116.0, $\chi^2(2) = 8.9$, $p = .01$), with the intrinsic frame of reference being the most significantly favored choice (z=2.6, $p = .008$) , as can be seen in Fig. 4.

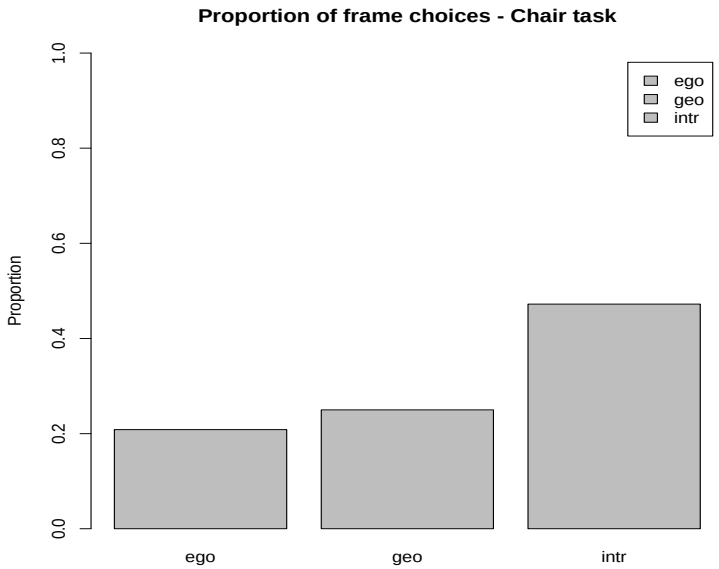

Fig. 4. Distribution of preferred frames of reference (egocentric, geocentric, and intrinsic)

The choice of the frame of reference is not affected by Sex or Education (loglikelihood is -113.9, $\chi^2(3) = 4.3$, $p = .22$). However, there are significant interactions of the frame of reference by Location of the performance (loglikelihood is -108.9, $\chi^2(3) = 14.3$, $p = .003$), with significantly least preferences of the geocentric frame of reference indoors (z=3, p= .003), and least preferences for the egocentric frame of reference outdoors (z=2.2, p =.03); see Fig. 5.

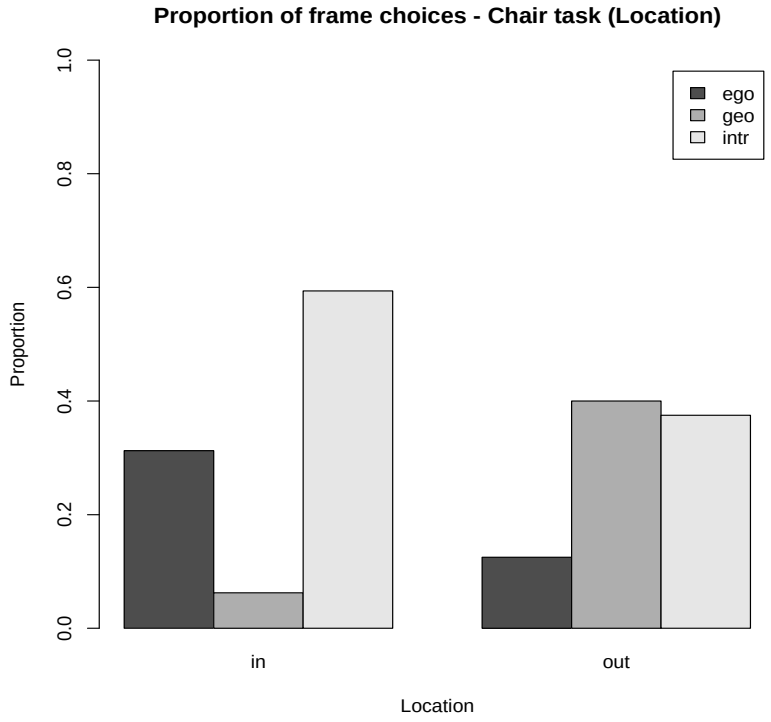

Fig. 5. Distribution of frames of reference with respect to the distinction of indoors/outdoors

2.3. Study 2

2.3.1. Goals and predictions

In order to exclude the intrinsic relation that was dominant in the task with the chair, a second experiment was conducted by positioning the objects on the ground.

2.3.2. Material

The Ixcatec participants were presented with a stimulus consisting of three everyday objects, of similar size: a soap bar, a matchbox, and a candle.

2.3.3. Participants

Participants as in study 1.

2.3.4. Procedure

For this task, the three items — the soap bar, the matchbox, and the candle — were first placed on the ground on a vertical axis. The participants were asked to memorize the placement of the objects. They were free to take the time they needed to memorize the placement of the objects. Participants were first asked to place the objects on the ground facing north, towards the main mountains. A picture was taken of the objects facing the participant. The participants were then immediately led three meters away from the first location and were rotated 180 degrees with respect to the first setting, thus facing south. In this position, the participants were asked to place the objects as they remembered them from the previous setting. The instructions were: "Could you please put the objects the way they were?" This procedure was repeated three times, with a random change in the order of the objects. The task lasted five minutes.

2.3.5. Coding and analysis

As in Study 1.

2.3.6. Results

In the egocentric frame of reference, in which relations between objects are calculated in relation to the speaker's point of view, the participants kept the relative order between the objects and themselves stable (Fig. 6a and 6b). In the geocentric frame of reference, participants placed the objects with respect to their absolute position once they had been rotated 180 degrees (see Fig. 7a and 7b). Nevertheless, the difference between geocentric frame and egocentric frame was not statistically significant ($z<1$).

Fig. 6a. Participant facing north: the soap bar is furthest from the participant

Fig. 6b. Participant facing south: the soap bar is furthest from the participant (egocentric frame of reference)

Fig. 7a. Participant facing north: the soap bar is northernmost

Fig. 7b. Participant facing south: the soap bar is northernmost (geocentric frame of reference)

In this task, there is again a marginal interaction of frame of reference by Education (the loglikelihood of the interaction is -109.1, $\chi^2(2) = 4.6$, $p = .09$), with significantly more participants with secondary education choosing the geocentric frame ($z=2.0$, $p = .047$). Fig. 8 illustrates the results for the preferred frame of reference with interactions of the factor Education.

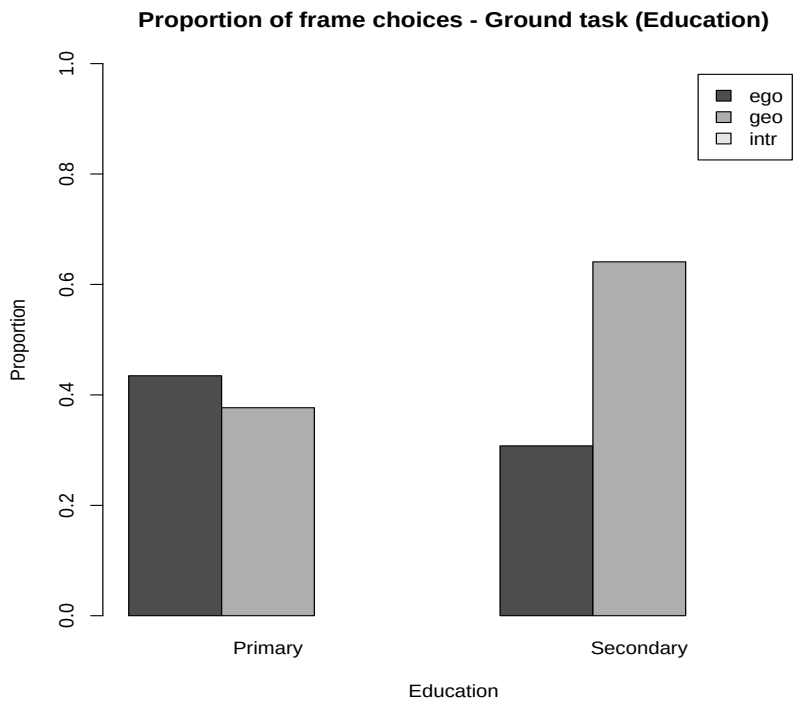

Fig. 8. Distribution of frames of reference with respect to Education

Fig. 9 illustrates the preference of the responses with respect to the factor Location, indoors/outdoors, following Li & Gleitman (2002). It can be seen that there was a larger difference between indoors and outdoors for the responses using a geocentric frame of reference (z=2.5, $p < .01$). There is also a marginal interaction of the Frames of reference by the Location of the task (loglikelihood of the interaction is -108.2, $\chi^2(3) = 7.2$, $p = .06$). This suggests that the environmental factor is a good predictor of the frame of reference for the ground task.

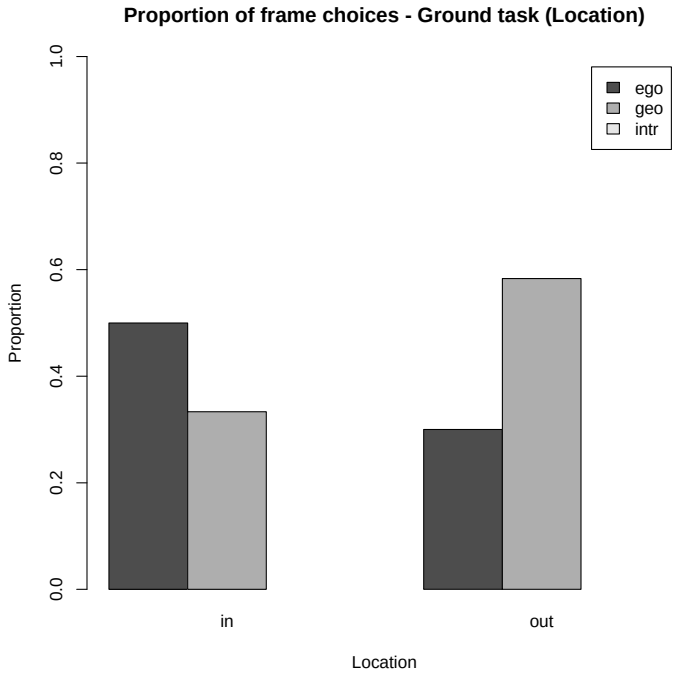

Fig. 9. Distribution of frames of reference with respect to the distinction of indoors/outdoors

2.4. Comparing the results of Study 1 and Study 2

2.4.1. Analysis

Generalized linear mixed models (glmer) were constructed using the "lme4" package (Bates et al. 2015) in R (R Core Team 2013) to analyze the results in the two tasks. The dependent variable is the counts for each frame of reference, and the independent variable is the three frame types (egocentric, geocentric, intrinsic). Speaker is coded as a random factor. Task (ground vs. chair), Education (primary vs. secondary), Sex (male vs. female), and the Location of the task (indoors vs. outdoors), were other fixed factors. Age being highly correlated with Education, was excluded from further analyses.

2.4.2. Results

The analysis of the two tasks shows that all three frames of reference are present among the participants. 30% of the choices are egocentric, 36% are geocentric, and 47% are intrinsic.

ANOVA shows no significant preference (the loglikelihood is -242.3, $\chi^2(2) = 1.3$, $p = .5$). However, further analyses show significant interaction of preferred Frame of reference by Task (the loglikelihood of the interaction is -227.5, $\chi^2(4) = 31.1$, $p < .001$), Frame of reference by Location (the loglikelihood of the interaction is -233.8, $\chi^2(5) = 18.3$, $p = .002$), and Frame of reference by Task by Location (the loglikelihood of the interaction is -227.3, $\chi^2(9) = 31.4$, $p < .001$). The proportion of the choice preferences can be seen in Fig. 10a and 10b.

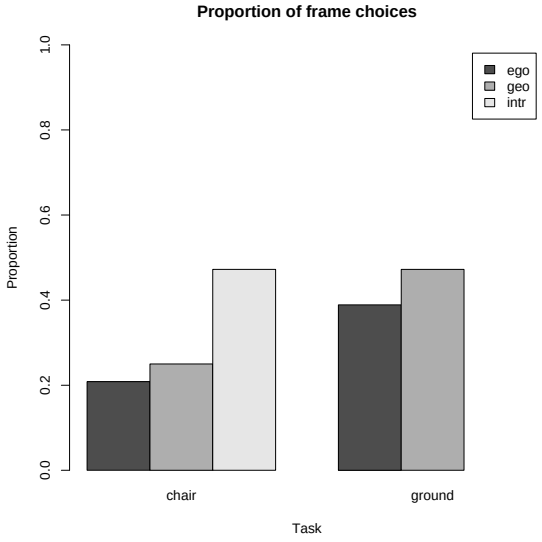

Fig. 10a. Distribution of frames of reference in the two tasks

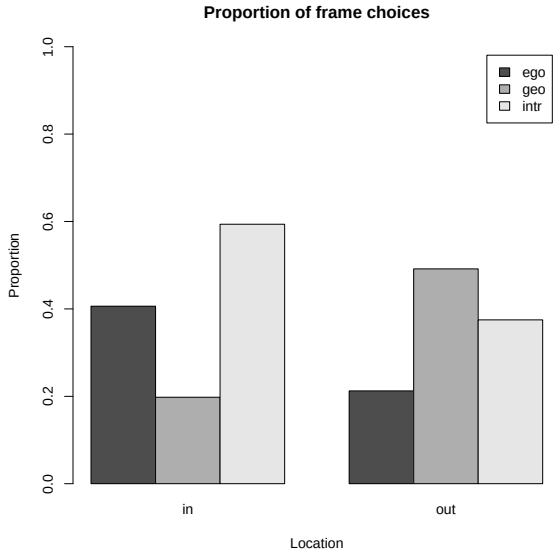

Fig. 10b. Distribution of frames of reference in the two tasks with respect to Location (indoors vs. outdoors)

The statistical analysis also shows that there is no interaction of Frame of reference by Sex ($\chi^2 < 1$), see Fig. 11a. However, there is a marginal interaction of Frame of reference by Education, as shown in Fig. 11b (the loglikelihood of the interaction is -238.3, $\chi^2(5) = 9.4$, $p = .09$). Specifically, significantly more secondary school educated participants chose the geocentric frame of reference ($z = 2.15$, $p = .03$).

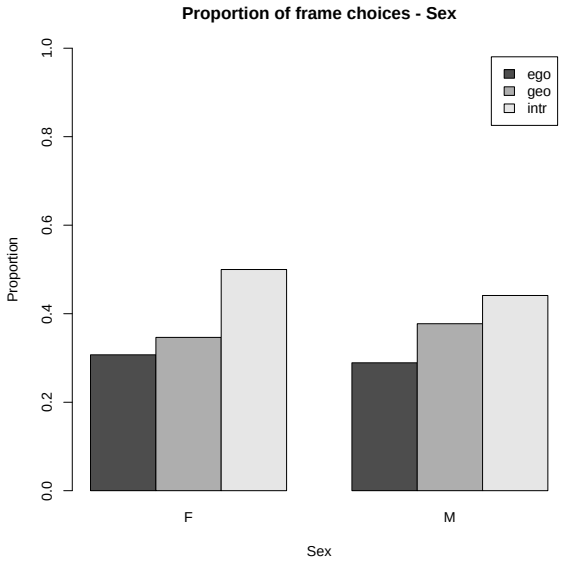

Fig. 11a. Distribution of frames of reference in the two tasks with respect to Sex

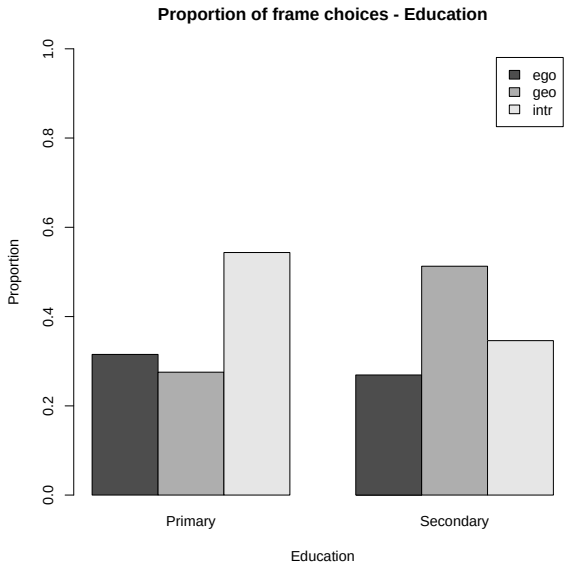

Fig. 11b. Distribution of frames of reference in the two tasks with respect to Education

2.5. Study 3

2.5.1. Goals and predictions

Study 1 and Study 2 show a correlation between secondary school education and a tendency towards using a geocentric frame of reference. Participants with solely primary school education strongly prefer the egocentric system. However, as in Study 1 and Study 2 the eldest participants were also the least educated ones, the correlation may also be due to age. In order to investigate the factors Education and Age, we conducted a similar experiment with young Ixcatecs who are currently attending primary school. According to the previous two studies, we expect the students of the primary school to prefer the egocentric frame of reference.

Moreover, similar to Study 1 and Study 2, the youngest generations are monolingual speakers of Spanish, which is known to favor egocentric frames of reference. We therefore expect that the young participants would strongly prefer the egocentric frame of reference.

Finally, as Study 1 and Study 2 showed that speakers who conducted the tasks outdoors were more sensitive to the environment and preferred the geocentric frame of reference, we conducted the task outdoors in order to balance the expected preference for an egocentric frame of reference.

2.5.2. Material

The participants were presented with a stimulus consisting of three Mexican handcrafted animal figures: a jaguar, a fish, and a chicken. The stimulus was placed on two school desks which had a trademark at the upper side; this mark was kept consistently closer to the participant independent of the rotation.

2.5.3. Participants

16 Ixcatecs, aged 10-11, participated in this study, three boys and thirteen girls. We note that this sample exhausts the population for this age group.

2.5.4. Procedure

The experiment was conducted at the school yard of the primary school. The three items - the jaguar, the fish, and the chicken - were first placed in a row, in the horizontal axis, on a school desk. Similar to Study 1, participants were first asked to place the objects on the desk facing north, towards the main mountains. A picture was taken of the objects facing the participant. The participants were then led to another school desk that was situated two meters away. They were then rotated 180 degrees with respect to the first setting, thus facing south, and were asked to place the objects again as they were. This procedure was repeated three times, with a random change in the order of the objects. The task lasted approximately five minutes.

Following the task, the results were discussed with the students and metalinguistic commentary was collected.

2.5.5. Coding and analysis

An excel file was created, with information about the speaker, age, and sex. The frame of reference was then coded as geocentric, and egocentric, or as an error if the setting was not correctly replicated. Moreover, the orientation of the animals with respect to the cardinal points was coded. Similar to the first study, generalized linear mixed models (glmer) were constructed using the "lme4" package (Bates et al. 2015) in R (R Core Team 2013) to analyze the results. The dependent variable is the counts for each reference frame, and the independent variable is the three frame types. Speaker is coded as a random factor.

2.5.6. Results

83% of the participants in this study used the geocentric frame of reference, shown in Fig. 12a and 12b, whereas 10% used the egocentric one, see Fig. 13a and 13b. The difference between the preferences is significant ($z=4.4$, $p < .001$); see Fig. 14.

We also note that in all but one case, the orientation of the animals towards east or west was correctly reproduced in the egocentric responses, see Fig. 13, thus excluding the interpretation of a purely intrinsic memorization of the stimuli, in which the only memorized element would be for example the fact that the jaguar is behind the fish independent of the placement with respect to the surroundings as argued in Danziger (2011: 856). Indeed, it appears that the young Ixcatecs, even when they rely on an egocentric frame of reference, they respect the orientation relative to the cardinal points.

Figure 12a. Participant facing north: the jaguar is easternmost and is facing east

Fig. 12b. Participant facing south: the jaguar is easternmost and is facing east (geocentric frame of reference)

Figure 13a. Participant facing north: the jaguar is at the participant's right hand, facing west

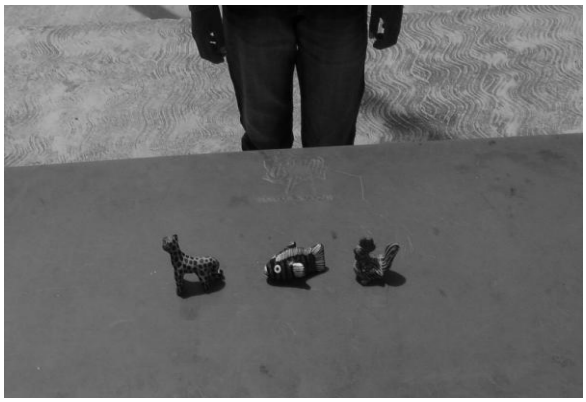

Fig. 13b. Participant facing south: the jaguar is at the participant's right hand, facing west (egocentric frame of reference with geocentric orientation)

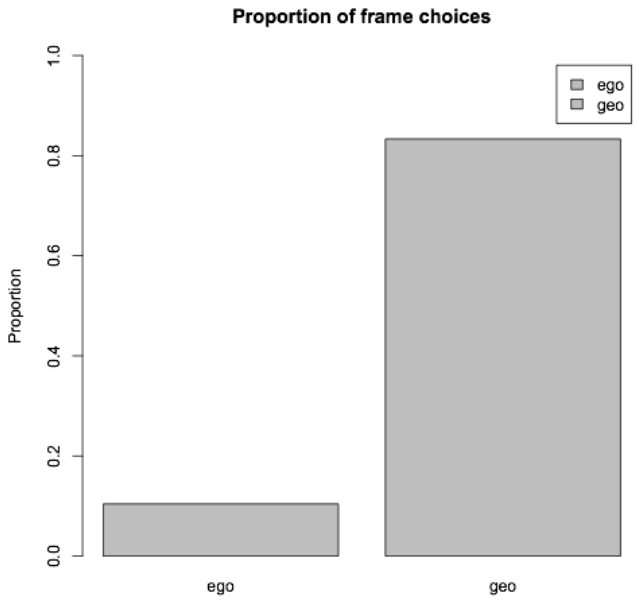

Fig. 14. Distribution of frames of reference in the "Animals in a row" task

Finally, we note that in the discussion that followed the experiment, the geocentric placement was considered as the most accurate by the majority of the students.

3. Discussion

With less than ten remaining Ixcatec speakers, Santa María Ixcatlán in Mexico presents itself as the perfect setting for examining the long-lasting effects of language on cognition. The most radical view of the Whorfian approach would predict that in case of language shift, spatial frames of reference would also be modified since language and cognition are related. An impact of language on spatial cognition is also shown for bilingual speakers of a Mesoamerican language and Spanish who use both a geocentric and an egocentric strategy in nonverbal experiments (Bohnemeyer et al., 2011; O'Meara & Peréz Báez, 2011; and for Ixcatec Adamou, in press). According to this approach, we expected that Spanish monolinguals in the community of Santa María Ixcatlán would use the egocentric frame of

reference, as it is more common in small-scale arrangements among Spanish speakers (Levinson, 2003).

Contrary to these expectations, our study shows that, despite the loss of the Ixcatec language, the geocentric frame of reference is in use amongst all the community members as it appeared in simple nonverbal tasks replicating the original task "Animals in a row". More specifically, Study 1 and Study 2 show that younger participants with secondary school education preferred the geocentric strategy, especially outdoors, and that the speakers with primary school education — mainly speakers over 60 — are underrepresented in the use of the geocentric system with a preference for the egocentric strategy. Study 3 shows that primary school students strongly prefer the geocentric frame of reference in simple, open-ended, memorization tasks, and that even when the egocentric frame of reference is preferred for the order of the stimuli, the geocentric frame of reference is correctly replicated as far as the orientation of the stimuli is concerned with respect to the cardinal points.

Our study thus demonstrates that in the case of the Ixcatec community, language does not align with spatial cognition. However, it is difficult to unambiguously interpret this result with respect to the rise of the frames of reference: it could be argued that our results demonstrate that the frames of reference are influenced by culture and environmental factors independent of language, following Li & Gleitman (2002), and thus that the geocentric responses developed independent of the Ixcatec language. But, it could also be said, following the neo-Whorfian studies, that the geocentric frame of reference was developed in the Ixcatec community under the influence of the Ixcatec spatial expressions but that this frame of reference was not lost at the moment of shift to Spanish and that it persists in the cognitive representations of the members of this stable, rural community (also see Meakins et al. in press).

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